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Agricultural Memorandum No 529
On the economics of cold stress on young beef cattle

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Summary

The consequences of cold stress on the individual animal of a farm group, in the average winter in Eastern England, have been set out in a number of ways. For a variety of ration mixes (ration concentrations) and for a variety of feed rates, information is presented in the form

- Air temperatures at which cold stress occurs ,as in Table 2.1.(iv)
- The rate of weight loss due to coldstress ,as in Table 2.3.(iv)

- Total weight loss due to coldstress ,as in Table 4.1.(ii)
- The supplementary period of keep to replace this loss ,as in Table 4.1.(iii)
- The supplementary amounts of feed to replace this loss ,as in Table 5.1.(i)

- Total weight loss due to coldstress when housing is provided, as in Tables 4.2.(ii) and 4.2.(iv)
- The supplementary period of keep to replace weight loss due to cold stress when housing is provided, as in Tables 4.2.(iii) and 4.2.(v)
- The supplementary amounts of feed to replace weight loss due to cold stress when housing is provided, as in Tables 5.1.(ii) and 5.1.(iii)

- The value of housing in terms of food saving through avoidance of coldstress and attendant weight loss as in Tables 5.2.(i) and 5.2.(ii).

1. Introduction

This note draws together the results of the analysis set out in Ag Mem 473 - Effect of winter environment on the growth of young beef cattle - and the more theoretical information set out in Ag. Memoranda 526 to 528 entitled respectively - Critical temperatures of young beef cattle; Simple computation of degree days; On the response of young beef cattle to cold.

2. Critical Temperatures

For convenience, Table 4 of Ag Mem No 528 is now reproduced

Estimates of the heat production of growing and fattening cattle (k cal/day)

Live weight (kg)	Ration Concentration (Mcal/kg DM)	Planned rate of gain (kg/day)						
		0	.25	.50	.75	1.00	1.25	1.50
200	1.8	8600	9936	11590	13815	-	-	-
	2.2	8300	9236	10190	11615	13430	-	-
	2.6	8000	8636	9290	10315	11430	12800	14550
	3.0	7700	8136	8590	9315	10430	11000	12150
	3.4	7500	7836	8090	8615	9430	9900	10550
300	1.8	10500	12130	13855	16380	-	-	-
	2.2	10200	11230	12455	13880	16070	-	-
	2.6	9800	10530	11355	12280	13770	15600	-
	3.0	9400	9930	10655	11180	12170	13300	14750
	3.4	9100	9530	9955	10380	11170	11800	12856
400	1.8	12400	14320	16310	19350	-	-	-
	2.2	12000	13320	14710	16650	18900	-	-
	3.0	11100	11820	12410	13250	14300	15700	17500
	3.4	10800	11320	11710	12250	13000	13900	15200
	2.6	11500	12420	13310	14750	16200	18300	-

These data have now to be converted into Critical Temperatures through the relationship

$$T_c = T_B - \frac{(H - H_W - H_E^1)}{AK}$$

where T_C represents the Critical Temperature

T_B represents the deep body temperature

H_W represents the body heat used in raising the temperature of the ration to body temperature

H_E^1 represents the (minimum) evaporative heat loss

A represents the surface area of the animal

K represents cooling constant or thermal conductance.

We evaluate T_C under various assumptions concerningK, the thermal conductance, viz

(i) Erected coat thickness is 20 mm.
The difference between the radiant and ambient air temperature of the environment is 3°C. ($T_R - T_A = 3°C$)
The mean free wind speed is 2.5 m/S.
The exponent of the multiplier for convective effects and for wind effects generally is 0.7 - see Ag Mem 526.

(ii) As above, except that the exponent of the multiplier for wind effects is 0.6

(iii) As above under "Still air" conditions, and with $T_R - T_A = 0°C$

(iv) The evaluation of Critical Temperatures under the above assumptions will depend on data derived from the calorimeter study of individual animals. To include the modifying effect on the individual, of its inclusion in a group in the farm situation, we make use of the Critical Temperature (5.3°C) established in Ag Mem 473 to derive a value for K. Such a value for K may then be employed to study the implications of feeding regimes other than that for which T_C was established initially. For an observed daily weight gain of Zero, for 200 kg animals fed on medium quality hay, we take the ration concentration to be 1.8 Mcal/kg.DM. (cf Ag Mem 473).

2.1 Results

Table 2.1(i) Critical Temperatures - exponent of wind effects 0.7

Live Weight	Ration Concentration	Planned rate of gain (kg/day)						
		0	.25	.50	.75	1.00	1.25	1.50
200	1.8	14.7°C	10.7	5.9	- 0.7	-	-	-
	2.2	15.6	12.8	10.0	5.8	0.5	-	-
	2.6	16.5	14.6	12.7	9.6	6.4	2.3	- 2.8
	3.0	17.3	16.1	14.7	12.6	9.3	7.6	4.2
	3.4	17.9	16.9	16.2	14.6	12.2	10.9	8.9
300	1.8	14.7	10.8	6.6	0.6	-	-	-
	2.2	15.4	12.9	10.0	6.6	1.3	-	-
	2.6	16.4	14.7	12.6	10.4	6.8	2.4	-
	3.0	17.3	16.0	14.3	13.0	10.7	8.0	4.5
	3.4	18.0	17.0	16.0	15.0	13.1	11.5	9.0
400	1.8	12.8	8.7	4.3	- 2.3	-	-	-
	2.2	13.7	10.8	7.8	3.5	- 1.3	-	-
	2.6	14.8	12.8	10.9	7.7	4.5	0.0	-
	3.0	15.7	14.1	12.8	11.0	8.7	5.6	1.7
	3.4	16.3	15.2	14.3	13.2	11.5	9.6	6.7

Table 2.1. (ii) Critical Temperatures - exponent of wind effects 0.6

Live Weight	Ration Concentration	Planned rate of gain (kg/day)						
		0	.25	.50	.75	1.00	1.25	1.50
200	1.8	13.5°C	9.4	4.3	- 2.5	-	-	-
	2.2	14.5	11.6	8.6	4.3	- 1.3	-	-
	2.6	15.4	13.4	11.4	8.3	4.8	0.6	- 4.8
	3.0	16.3	15.0	13.6	11.3	7.9	6.0	2.6
	3.4	16.9	15.9	15.1	13.5	11.0	9.5	7.5
300	1.8	13.5	9.4	5.1	- 1.2	-	-	-
	2.2	14.3	11.7	8.6	5.0	- 0.5	-	-
	2.6	15.3	13.5	11.4	9.0	5.3	0.7	-
	3.0	16.3	15.0	13.1	11.8	9.3	6.5	2.8
	3.4	17.0	16.0	14.9	13.8	11.8	10.3	7.6
400	1.8	11.6	7.3	2.7	- 4.3	-	-	-
	2.2	12.5	9.5	6.3	1.9	- 3.2	-	-
	2.6	13.7	11.5	9.5	6.2	2.9	- 1.9	-
	3.0	14.6	12.9	11.5	9.7	7.3	4.1	0.0
	3.4	15.3	14.1	13.2	11.9	10.2	8.2	5.2

Table 2.1. (iii) Critical Temperatures - "still air"

Live Weight	Ration Concentration	Planned rate of gain (kg/day)						
		0	.25	.50	.75	1.00	1.25	1.50
200	1.8	- 0.8	- 7.3	- 15.3	- 26.0	-	-	-
	2.2	0.6	- 3.9	- 8.5	- 15.4	- 24.2	-	-
	2.6	2.0	- 1.0	- 4.2	- 9.1	- 14.5	- 21.1	- 29.6
	3.0	3.5	1.4	- 0.8	- 4.3	- 9.7	- 12.4	- 18.0
	3.4	4.5	2.9	1.6	- 0.9	- 4.8	- 7.1	- 10.3
300	1.8	- 0.9	- 7.3	- 14.1	- 24.1	-	-	-
	2.2	0.3	- 3.8	- 8.6	- 14.2	- 22.9	-	-
	2.6	1.8	- 1.0	- 4.3	- 7.9	- 13.8	- 21.0	-
	3.0	3.4	1.3	- 1.5	- 3.6	- 7.5	- 12.0	- 17.7
	3.4	4.6	2.9	1.2	- 0.4	- 3.6	- 6.0	- 10.2
400	1.8	- 4.0	- 10.8	- 18.0	- 28.8	-	-	-
	2.2	- 2.5	- 7.3	- 12.4	- 19.2	- 27.2	-	-
	2.6	- 0.8	- 4.0	- 7.2	- 12.4	- 17.6	- 25.1	-
	3.0	0.7	- 1.9	- 4.0	- 7.0	- 10.8	- 15.8	- 22.2
	3.4	1.7	- 0.1	- 1.5	- 3.4	- 6.1	- 9.3	- 14.0

Table 2.1. (iv) Critical Temperatures - individual of farm group

Live Weight	Ration Concentration	Planned rate of gain (kg/day)						
		0	.25	.50	.75	1.00	1.25	1.50
200	1.8	5.3	- 0.3	- 7.2	- 16.5	-	-	-
	2.2	6.5	2.6	- 1.4	- 7.3	- 14.9	-	-
	2.6	7.7	5.1	2.4	- 1.9	- 6.5	- 12.3	- 19.5
	3.0	9.0	7.2	5.3	2.3	- 2.4	- 4.7	- 9.5
	3.4	9.8	8.4	7.4	5.2	1.8	- 0.2	- 2.9
300	1.8	5.1	- 0.5	- 6.3	- 14.9	-	-	-
	2.2	6.1	2.6	- 1.6	- 6.4	- 13.9	-	-
	2.6	7.5	5.0	2.2	- 1.0	- 6.0	- 12.3	-
	3.0	8.8	7.0	4.5	2.8	- 0.6	- 4.4	- 9.4
	3.4	9.8	8.4	6.9	5.5	2.8	0.7	- 2.9
400	1.8	2.4	- 3.5	- 9.6	- 19.0	-	-	-
	2.2	3.6	- 0.4	- 4.7	- 10.7	- 17.7	-	-
	2.6	5.2	2.3	- 0.4	- 4.9	- 9.3	- 15.8	-
	3.0	6.4	4.2	2.3	- 0.2	- 3.5	- 7.8	- 13.3
	3.4	7.3	5.7	4.5	2.9	0.5	- 2.2	- 6.2

2.2 Results

Table 2.2 (i) Values for K - exponent of wind effects 0.7

Live Weight	Ration Concentration	Planned rate of gain (kg/day)						
		0	.25	.50	.75	1.00	12.5	1.50
200	1.8	82.8	83.1	83.4	83.6	-	-	-
	2.2	82.7	83.0	83.7	83.4	83.6	-	-
	2.6	82.7	82.8	83.0	83.2	83.4	83.5	83.7
	3.0	82.5	82.7	82.8	83.0	83.2	83.3	83.4
	3.4	82.5	82.6	82.7	82.8	83.0	83.1	83.2
300	1.8	83.2	83.5	83.6	83.9	-	-	-
	2.2	83.2	83.3	83.5	83.7	83.8	-	-
	2.6	83.1	83.2	83.3	83.5	83.6	83.8	-
	3.0	83.0	83.1	83.2	83.3	83.5	83.6	83.7
	3.4	82.9	83.0	83.1	83.2	83.3	83.4	83.5
400	1.8	83.5	83.7	83.9	84.0	-	-	-
	2.2	83.4	83.6	83.7	83.9	84.0	-	-
	2.6	83.4	83.5	83.6	83.7	83.8	84.0	-
	3.0	83.3	83.4	83.5	83.6	83.7	83.8	83.9
	3.4	83.3	83.3	83.4	83.5	83.6	83.7	83.8

The range of K above is from 82.5 - 84.0. This effectively constant value for K is understandable if one recalls that the heat loss is essentially determined by the external environment.

(ii) Values for K - exponent of wind effects 0.6

Range of K, 78.9 - 80.3

(iii) Values for K - "still air"

Range of K, 50.8 - 51.4

(iv) Values for K - individual of farm group

Value of K, 60

This value of K = 60 is obtained from a completely independent set of data. It falls between the theoretical minimum value for K based on calorimeter data (K = 50.8 to 51.4) and the values of K obtained when calorimeter data for individual animals are extrapolated to the farm situation (K = 78.9 - 84.0).

2.3 Results

Weight loss per day deg . Centigrade below T_C (cf Ag.Memo 528)

Table 2.3. (i) With exponent of wind effects 0.7

Live Weight	Ration Concentration	Planned rate of gain (kg/day)						
		0	.25	.50	.75	1.00	1.25	1.50
200	1.8	43.0g	43.2	43.4	43.5	-	-	-
	2.2	43.0	43.2	43.3	43.4	43.5	-	-
	2.6	43.0	43.0	43.2	43.3	43.4	43.4	43.5
	3.0	42.9	43.0	43.0	43.2	43.3	43.3	43.4
	3.4	42.9	43.0	43.0	43.0	43.2	43.2	43.3
300	1.8	53.0	53.2	53.3	53.4	-	-	-
	2.2	53.0	53.1	53.2	53.3	53.4	-	-
	2.6	52.9	53.0	53.1	53.2	53.3	53.4	-
	3.0	52.9	52.9	53.0	53.1	53.2	53.3	53.3
	3.4	52.8	52.9	52.9	53.0	53.1	53.1	53.2
400	1.8	58.6	58.7	58.9	59.0	-	-	-
	2.2	58.5	58.7	58.7	58.9	59.0	-	-
	2.6	58.5	58.6	58.7	58.7	58.8	59.0	-
	3.0	58.5	58.5	58.6	58.7	58.7	58.8	58.9
	3.4	58.5	58.5	58.5	58.6	58.7	58.7	58.8

Weight loss per day deg. Centigrade - below T_C

Table 2.3. (ii) With exponent of wind effects 0.6

Live Weight	Location Concentration	Planned rate of gain (kg/day)						
		0	.25	.50	.75	1.00	1.25	1.50
200	1.8	41.2g	41.3	41.4	41.5	-	-	-
	2.2	41.1	41.2	41.3	41.4	41.5	-	-
	2.6	41.1	41.2	41.2	41.3	41.4	41.4	41.5
	3.0	41.0	41.1	41.2	41.2	41.3	41.4	41.4
	3.4	41.0	41.1	41.1	41.2	41.2	41.3	41.3
300	1.8	50.6	50.8	50.9	51.0	-	-	-
	2.2	50.6	50.7	50.8	50.9	51.0	-	-
	2.6	50.6	50.6	50.8	50.8	50.9	51.0	-
	3.0	50.5	50.6	50.7	50.7	50.8	50.9	51.0
	3.4	50.5	50.6	50.6	50.6	50.7	50.8	50.8
400	1.8	56.0	56.2	56.2	56.3	-	-	-
	2.2	55.9	56.1	56.2	56.2	56.3	-	-
	2.6	55.9	56.0	56.1	56.2	56.2	56.3	-
	3.0	55.9	55.9	56.0	56.1	56.2	56.2	56.3
	3.4	55.9	55.9	55.9	56.0	56.0	56.2	56.2

Weight loss per day deg. Centigrade below T_C

Table 2.3. (iii) Under "still air" conditions

Live Weight	Location Concentration	Planned rate of gain (kg/day)						
		0	.25	.50	.75	1.00	1.25	1.50
200	1.8	26.5g	26.6	26.6	26.7	-	-	-
	2.2	26.5	26.5	26.6	26.6	26.6	-	-
	2.6	26.5	26.5	26.5	26.6	26.6	26.6	26.7
	3.0	26.5	26.5	26.5	26.5	26.6	26.6	26.6
	3.4	26.4	26.5	26.5	26.5	26.5	26.6	26.6
300	1.8	32.5	32.6	32.7	32.7	-	-	-
	2.2	32.5	32.5	32.6	32.6	32.7	-	-
	2.6	32.5	32.5	32.5	32.6	32.7	32.7	-
	3.0	32.5	32.5	32.5	32.5	32.6	32.6	32.7
	3.4	32.5	32.5	32.5	32.5	32.5	32.6	32.6
400	1.8	35.9	36.0	36.0	36.1	-	-	-
	2.2	35.9	35.9	36.0	36.0	36.1	-	-
	2.6	35.9	35.9	35.9	36.0	36.0	36.1	-
	3.0	35.9	35.9	35.9	35.9	36.0	36.0	36.1
	3.4	35.9	35.9	35.9	35.9	35.9	36.0	36.0

Weight Loss Per Day Deg. Centigrade Below T_c

Table 2.3 (iv) Individual of farm group

Liveweight	Ration Concentration	Planned rate of gain (kg/day) 0 - 1.50
200	1.8 - 3.4	31.2 g
300	1.8 - 3.4	34.2
400	1.8 - 3.4	42.1

3. Frequency of Cold Stress

The accumulation of day degrees Centigrade below various bases for a typical sample of years, for a site in East Anglia is shown in the following table.

Table 3

Base/Year	1	2	3	4	5	6	7	8	9	10	Average Season
0 C	8	12	22	30	41	46	53	70	87	129	50
- 0.7	18	42	55	66	83	95	112	131	170	235	101
1.3	62	91	124	140	162	190	219	250	290	400	193
3.3	131	172	219	253	285	322	345	400	448	555	313
5.3	240	300	360	400	449	492	541	600	745	800	413
7.3	393	494	568	655	668	720	772	832	910	1070	601
9.3	595	710	790	865	920	985	1030	1100	1190	1415	960
11.3	850	1010	1080	1140	1220	1280	1340	1400	1500	1650	1247
13.3											

We may make 2 comments:

(i) The frequency of exposure to cold stress at Critical Temperatures below 0°C is not likely to be a significant factor in beef production.

(ii) Year 6 of the sample years 1-10 is a fair approximation to the average season. Interpolation over the distribution of degree days obtained with year 6 for a sample of bases, to obtain for the average season degree days to be associated with any base, would seem justified.

4. Charges on production

4.1 The Normal Environment

We may combine the data of:

Section 2.1 (iv) - Critical Temperatures of the individual of a farm group

Section 2.2 (iv) - Values for K for the individual of a farm group

Section 2.3 (iv) - Weight loss per day degree Centigrade below T_c, for the individual of a farm group

Section 3 - Accumulated day degrees below various bases.

This leads to the following information:-

Table 4 (ii). Accumulated day degrees (DD). Centigrade below the Critical Temperature, appropriate to a nominated ration concentration and planned rate of live weight gain, for the individual of a farm group in the average season.

Liveweight	Ration Concentration	Planned rate of gain (kg/day)						
		0	.25	.50	.75	1.00	1.25	1.50
200	1.8	322 DD	57	-	-	-	-	-
	2.2	425	155	-	-	-	-	-
	2.6	535	305	147	-	-	-	-
	3.0	677	477	322	142	-	-	-
	3.4	795	707	505	312	165	90	-
300	1.8	307	50	-	-	-	-	-
	2.2	387	155	-	-	-	-	-
	2.6	512	300	137	-	-	-	-
	3.0	655	465	262	165	48	-	-
	3.4	795	707	455	340	165	85	-
400	1.8	147	-	-	-	-	-	-
	2.2	205	55	-	-	-	-	-
	2.6	312	143	55	-	-	-	-
	3.0	412	242	143	60	-	-	-
	3.4	492	355	262	170	80	-	-

These data may be converted to an expected weight loss due to cold stress during the winter season.

Table 4.1 (ii). Weight loss due to cold stress over or during the average winter season, associated with nominated ration concentrations and planned rate of liveweight gain, for the individual of a farm group.

Liveweight	Ration Concentration	Planned rate of gain (kg/day)						
		0	.25	.50	.75	1.00	1.25	1.50
200	1.8	10.05 kg	1.78	-	-	-	-	-
	2.2	13.26	4.84	-	-	-	-	-
	2.6	16.69	9.59	4.59	-	-	-	-
	3.0	21.12	14.88	10.05	4.43	-	-	-
	3.4	24.80	22.06	15.76	9.73	5.12	2.81	-
300	1.8	10.50	1.71	-	-	-	-	-
	2.2	13.23	5.30	-	-	-	-	-
	2.6	17.51	10.26	4.69	-	-	-	-
	3.0	22.40	15.90	8.97	5.64	1.64	-	-
	3.4	27.19	24.18	15.56	11.83	5.64	2.91	-
400	1.8	6.19	-	-	-	-	-	-
	2.2	8.63	2.31	-	-	-	-	-
	2.6	13.13	6.02	2.31	-	-	-	-
	3.0	17.35	10.19	6.02	2.53	-	-	-
	3.4	20.71	14.95	11.03	7.16	3.37	-	-

Table 4.1 (iii). Supplementary period of keep (in days) to replace weight loss due to cold stress over the average winter season

Liveweight	Ration Concentration	Planned rate of gain (kg/day)						
		0	.25	.50	.75	1.00	1.25	1.50
200	1.8	INDEFINITE	8	-	-	-	-	-
	2.2		20	-	-	-	-	-
	2.6		38	10	-	-	-	-
	3.0		60	20	6	-	-	-
	3.4		88	32	13	6	3	-
300	1.8		7	-	-	-	-	-
	2.2		22	-	-	-	-	-
	2.6		4	10	-	-	-	-
	3.0		64	18	8	2	-	-
	3.4		97	32	16	6	3	-
400	1.8		-	-	-	-	-	-
	2.2		10	-	-	-	-	-
	2.6		24	5	-	-	-	-
	3.0		41	12	4	-	-	-
	3.4		60	22	10	4	-	-

The data of the last 3 tables may be considered to represent the charges on production in the average season, if no steps are taken either to modify the environmental temperature (for example by housing or shelter), or to change the feeding regime (to obtain a lower critical temperature) under cold stress conditions.

4.2 Housed Animals

If housing is provided which raises the internal air temperature 1°C above the ambient, outside air temperature, then we may assess the value of such housing by repeating the calculations shown in the last 3 tables for Critical Temperatures which are lowered by 1°C.

Table 4.2 (i). Accumulated day degrees (DD) Centigrade below the Critical Temperature over or during the average winter season, for the individual of a farm group (1°C lift)

Liveweight	Ration Concentration	Planned rate of liveweight gain kg/day						
		0	.25	.50	.75	1.00	1.25	1.50
200	1.8	250 DD	-	-	-	-	-	-
	2.2	322	117	-	-	-	-	-
	2.6	440	230	107	-	-	-	-
	3.0	562	398	250	105	-	-	-
	3.4	652	502	415	242	90		
300	1.8	232	-	-	-	-	-	-
	2.2	305	115	-	-	-	-	-
	2.6	430	230	100	-	-	-	-
	3.0	542	380	200	122	-	-	-
	3.4	655	505	372	265	122	55	-
400	1.8	100	-	-	-	-	-	-
	2.2	155	-	-	-	-	-	-
	2.6	242	95	-	-	-	-	-
	3.0	330	182	95	-	-	-	-
	3.4	402	275	200	120	50	-	-

Table 4.2 (ii). Weight loss due to cold stress over or during the average winter season for the individual of a farm group. (1°C lift)

Liveweight	Ration Concentration	Planned rate of liveweight gain kg/day						
		0	.25	.50	.75	1.00	1.25	1.50
200	1.8	7.80 kg	-	-	-	-	-	-
	2.2	10.05	3.65	-	-	-	-	-
	2.6	13.73	7.18	3.34	-	-	-	-
	3.0	17.53	12.42	7.80	3.28	-	-	-
	3.4	20.34	15.66	12.95	7.55	2.81	-	-
300	1.8	7.93	-	-	-	-	-	-
	2.2	10.43	3.93	-	-	-	-	-
	2.6	14.71	7.87	3.42	-	-	-	-
	3.0	18.54	13.00	6.84	4.17	-	-	-
	3.4	22.40	17.27	12.72	9.06	4.17	1.88	-
400	1.8	4.21	-	-	-	-	-	-
	2.2	6.53	-	-	-	-	-	-
	2.6	10.19	4.00	-	-	-	-	-
	3.0	13.89	7.66	4.00	-	-	-	-
	3.4	16.92	11.58	8.42	5.05	2.10	-	-

Table 4.2 (iii). Supplementary period of keep (in days) to replace weight loss due to cold stress over the average winter season (1°C lift)

Liveweight	Ration Concentration	Planned rate of liveweight gain (kg/day)						
		0	.25	.50	.75	1.00	1.25	1.50
200	1.8	INDEFINITE	-	-	-	-	-	-
	2.2		15	-	-	-	-	-
	2.6		29	7	-	-	-	-
	3.0		50	16	5	-	-	-
	3.4		63	26	10	3	-	-
300	1.8		-	-	-	-	-	-
	2.2		16	-	-	-	-	-
	2.6		32	7	-	-	-	-
	3.0		52	14	6	-	-	-
	3.4		69	26	12	4	2	-
400	1.8		-	-	-	-	-	-
	2.2		-	-	-	-	-	-
	2.6		16	-	-	-	-	-
	3.0		31	8	-	-	-	-
	3.4		47	17	7	3	-	-

For housing which provides a 2°C lift of the air temperature we have:-

Table 4.2 (iv). Accumulated day degrees (DD) Centigrade below the Critical Temperature over or during the average winter season, for the individual of a farm group (2°C lift)

Liveweight	Ration Concentration	Planned rate of liveweight gain (kg/day)						
		0	.25	.50	.75	1.00	1.25	1.50
200	1.8	190	-	-	-	-	-	-
	2.2	262	75	-	-	-	-	-
	2.6	355	177	70	-	-	-	-
	3.0	465	307	190	67	-	-	-
	3.4	545	415	330	182	55	-	-
300	1.8	177	-	-	-	-	-	-
	2.2	235	105	-	-	-	-	-
	2.6	337	170	65	-	-	-	-
	3.0	450	300	145	80	-	-	-
	3.4	540	415	290	200	80	-	-
400	1.8	70	-	-	-	-	-	-
	2.2	107	-	-	-	-	-	-
	2.6	182	67	-	-	-	-	-
	3.0	255	130	67	-	-	-	-
	3.4	322	155	145	85	-	-	-

5. The Ration Mix

It is of interest to consider the quantities of feed involved in keeping the animals, since this provides one measure of the charges on production, due to cold stress, if the animals are taken to a nominated weight before disposal.

Good quality ryegrass hay is taken to have a metabolisable energy content of 1.96 MCal/kg DM. The appropriate figure for barley grain is taken as 3.09 Mcal/kg DM. These feeds are taken to constitute the animals ration as far as possible; we note that to meet the extreme ration concentrations of 1.8 and 3.4 Mcal/kg DM it becomes necessary to consider moderate quality hay and (ground nut) cake respectively.

Section 4 above indicates that we may neglect the effects of cold stress on animals for which the planned liveweight gain is greater than 1 kg per day.

The relevant part of Table 1, Ag Mem 528, which shows estimates of the metabolisable energy requirements of growing and fattening cattle (under no cold stress) is now restated in terms of the above ration mix components.

Table 5. Components of dairy ration mix (kg) to obtain nominated liveweight gains

Liveweight	Ration Concentration	Planned rate of liveweight gain (kg/day)															
		0				.25				.50				.75				1.00			
		H_1	H_2	B	C	H_1	H_2	B	C	H_1	H_2	B	C	H_1	H_2	B	C	H_1	H_2	B	C
200	1.8	4.8	-	-	-	5.8	-	-	-	7.2	-	-	-	8.8	-	-	-	-	-	-	-
	2.2	-	3.0	0.8	-	-	3.5	1.0	-	-	4.1	1.1	-	-	4.9	1.3	-	-	5.9	1.5	-
	2.6	-	1.3	1.8	-	-	1.5	2.0	-	-	1.8	2.3	-	-	2.0	2.7	-	-	2.4	3.1	-
	3.0	-	0.2	2.4	-	-	0.2	2.7	-	-	0.3	3.0	-	-	0.3	3.5	-	-	0.3	4.0	-
	3.4	-	-	-	2.2	-	-	-	2.5	-	-	-	2.8	-	-	-	3.1	-	-	-	3.5
300	1.8	5.8	-	-	-	7.1	-	-	-	8.5	-	-	-	10.4	-	-	-	-	-	-	-
	2.2	-	3.6	1.0	-	-	4.3	1.1	-	-	5.0	1.3	-	-	5.8	1.6	-	-	7.0	1.9	-
	2.6	-	1.6	2.2	-	-	1.9	2.4	-	-	2.1	2.8	-	-	2.5	3.2	-	-	2.9	3.7	-
	3.0	-	0.3	2.9	-	-	0.3	3.2	-	-	0.3	3.7	-	-	0.4	4.1	-	-	0.4	4.8	-
	3.4	-	-	-	2.7	-	-	-	3.0	-	-	-	3.3	-	-	-	3.8	-	-	-	4.3
400	1.8	6.9	-	-	-	8.4	-	-	-	10.0	-	-	-	12.3	-	-	-	-	-	-	-
	2.2	-	4.3	1.2	-	-	5.0	1.4	-	-	5.9	1.6	-	-	6.9	1.9	-	-	8.2	2.2	-
	2.6	-	1.9	2.5	-	-	2.2	2.9	-	-	2.5	3.3	-	-	2.9	3.8	-	-	3.3	4.5	-
	3.0	-	0.3	3.4	-	-	0.3	3.9	-	-	0.4	4.3	-	-	0.4	4.6	-	-	0.5	5.6	-
	3.4	-	-	-	3.2	-	-	-	3.5	-	-	-	3.9	-	-	-	4.4	-	-	-	5.0

where H_1 represents medium quality hay (kg)

H_2 represents good quality hay (kg)

B represents barley grain (kg)

C represents cake (kg)

The information in the above table may be combined with that in section 4 above, in the supplementary period of keep necessary to replace the weight loss due to cold stress over the winter, to give a further measure of the charges on production due to cold stress.

Table 5.1 (i). Total ration (kg) to replace the weight loss due to cold stress over the average winter season

Liveweight	Ration Concentration	Planned rate of liveweight gain (kg/day)															
		0	.25				.50				.75				1.00			
			H_1	H_2	B	C	H_1	H_2	B	C	H_1	H_2	B	C	H_1	H_2	B	C
200	1.8	INDEFINITE	46	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.2		-	70	20	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.6		-	57	76	-	-	18	23	-	-	-	-	-	-	-	-	-
	3.0		-	12	162	-	-	6	60	-	-	2	21	-	-	-	-	-
	3.4		-	-	-	220	-	-	-	90	-	-	-	41	-	-	-	21
300	1.8		50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.2		-	95	24	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.6		-	78	98	-	-	21	28	-	-	-	-	-	-	-	-	-
	3.0		-	19	205	-	-	5	67	-	-	2	33	-	-	1	10	-
	3.4		-	1	-	291	-	-	-	106	-	-	-	61	-	-	-	26
400	1.8		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.2		-	50	14	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.6		-	53	70	-	-	13	17	-	-	-	-	-	-	-	-	-
	3.0		-	12	131	-	-	5	52	-	-	2	18	-	-	-	-	-
	3.4		-	-	-	210	-	-	-	86	-	-	-	44	-	-	-	20

Table 5.1 (ii). Total ration (kg) to replace the weight loss due to cold stress over the average season (Housing providing 1°C lift)

Liveweight	Ration Concentration	Planned rate of liveweight gain (kg/day)															
		0	.25				.50				.75				1.00			
			H_1	H_2	B	C	H_1	H_2	B	C	H_1	H_2	B	C	H_1	H_2	B	C
200	1.8	INDEFINITE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.2		-	53	15	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.6		-	44	58	-	-	13	16	-	-	-	-	-	-	-	-	-
	3.0		-	10	135	-	-	5	48	-	-	2	18	-	-	-	-	-
	3.4		-	-	-	145	-	-	-	73	-	-	-	31	-	-	-	10
300	1.8		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.2		-	69	18	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.6		-	61	77	-	-	15	20	-	-	-	-	-	-	-	-	-
	3.0		-	16	166	-	-	5	52	-	-	2	25	-	-	-	-	-
	3.4		-	-	-	207	-	-	-	86	-	-	-	46	-	-	-	17
400	1.8		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.2		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.6		-	35	46	-	-	-	-	-	-	-	-	-	-	-	-	-
	3.0		-	9	121	-	-	3	34	-	-	-	-	-	-	-	-	-
	3.4		-	-	-	165	-	-	-	66	-	-	-	31	-	-	-	15

(kg)

Table 5.1 (iii). Total ration/to replace weight loss due to cold stress over the average season (Housing providing 2°C lift)

Liveweight	Ration Concentration	Planned rate of liveweight gain (kg/day)															
		0	.25				.50				.75				1.00			
			H_1	H_2	B	C	H_1	H_2	B	C	H_1	H_2	B	C	H_1	H_2	B	C
200	1.8	INDEFINITE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.2		-	35	10	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.6		-	33	44	-	-	9	11	-	-	-	-	-	-	-	-	-
	3.0		-	8	105	-	-	4	36	-	-	1	11	-	-	-	-	-
	3.4		-	-	-	130	-	-	-	59	-	-	-	25	-	-	-	7
300	1.8		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.2		-	65	17	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.6		-	46	58	-	-	11	14	-	-	-	-	-	-	-	-	-
	3.0		-	12	131	-	-	3	37	-	-	2	16	-	-	-	-	-
	3.4		-	-	-	171	-	-	-	66	-	-	-	34	-	-	-	13
400	1.8		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.2		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.6		-	16	35	-	-	-	-	-	-	-	-	-	-	-	-	-
	3.0		-	7	86	-	-	2	26	-	-	-	-	-	-	-	-	-
	3.4		-	-	-	95	-	-	-	43	-	-	-	22	-	-	-	-

The value of housing in avoiding cold stress may now be expressed in terms of the saving of feed that would be made, if the animals were taken through to a nominated weight before disposal.

Table 5.2 (i). Food saving (kg) in the average winter if housing providing a 1°C lift

Liveweight	Ration Concentration	Planned rate of liveweight gain (kg/day)															
		0	.25				.50				.75				1.00			
			H_1	H_2	B	C	H_1	H_2	B	C	H_1	H_2	B	C	H_1	H_2	B	C
200	1.8	INDEFINITE	46	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.2		-	17	5	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.6		-	13	16	-	-	5	7	-	-	-	-	-	-	-	-	-
	3.0		-	2	27	-	-	1	12	-	-	-	3	-	-	-	-	-
	3.4		-	-	-	75	-	-	-	17	-	-	-	10	-	-	-	11
300	1.8		50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.2		-	26	6	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.6		-	17	21	-	-	6	8	-	-	-	-	-	-	-	-	-
	3.0		-	3	39	-	-	-	15	-	-	-	8	-	-	1	10	-
	3.4		-	-	-	84	-	-	-	20	-	-	-	15	-	-	-	9
400	1.8		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.2		-	50	14	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.6		-	18	24	-	-	13	17	-	-	-	-	-	-	-	-	-
	3.0		-	3	10	-	-	2	18	-	-	2	18	-	-	-	-	-
	3.4		-	-	-	45	-	-	-	20	-	-	-	13	-	-	-	5

Table 5.2 (ii). Food saving (kg) in the average winter of housing providing a 2°C lift

Liveweight	Ration Concentration	Planned rate of liveweight gain (kg/day)														
		0	.25				.50				.75				1.00			
			H_1	H_2	B	C	H_1	H_2	B	C	H_1	H_2	B	C	H_1	H_2	B	C
200	1.8	INDEFINITE	46	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.2		-	35	10	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.6		-	24	32	-	-	9	12	-	-	-	-	-	-	-	-	-
	3.0		-	4	57	-	-	2	24	-	-	1	10	-	-	-	-	-
	3.4		-	-	-	90	-	-	-	31	-	-	-	16	-	-	-	14
300	1.8		50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.2		-	30	7	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.6		-	32	40	-	-	10	14	-	-	-	-	-	-	-	-	-
	3.0		-	7	74	-	-	2	30	-	-	-	17	-	-	-	-	-
	3.4		-	-	-	120	-	-	-	40	-	-	-	25	-	-	-	13
400	1.8		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.2		-	50	14	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.6		-	37	35	-	-	13	17	-	-	-	-	-	-	-	-	-
	3.0		-	5	45	-	-	3	26	-	-	2	18	-	-	-	-	-
	3.4		-	-	-	115	-	-	-	43	-	-	-	22	-	-	-	20

6. DISCUSSION

i. The message of all the data presented is that in cold stress situations there are physical advantages in rations of low energy concentrations, compared with rations of high energy concentrations. Heat output is thereby increased and cold stress reduced.

Limitations may be imposed by the voluntary food intake of the animals already on low ration concentrations, but nevertheless, one obvious management option is to make more hay or straw available in cold weather situations. The implication of Table 2.1 (iv) and Table 5, taken together, is that an additional intake of 1 kg of hay per day will have the effect of lowering the Critical Temperature by 3°-5°C and this is a measure of the protection afforded. A further comment is that the higher total energy intake will, if such a change in Critical Temperature is adequate to avoid cold stress, not only avoid weight loss, but in general lead to some positive weight gain; in such a situation it would seem legitimate to include both effects in any estimate of the marginal value of supplementary fodder fed at this time.

ii. The inference from Tables 5.1, where we consider the additional feed required to replace weight loss due to cold stress, is that where mixed rations of hay and grain are being fed (ration concentrations 2.2 - 3.0), there are cost advantages in lower ration concentrations, up to the point where the cost of obtaining good quality hay is about 3 times that of obtaining feed grains.

For the foreseeable future, low ration concentrations must also be cost advantageous in nullifying the effects of cold stress.

iii. If one may state the obvious, the value of housing in the avoidance of cold stress decreases rapidly as one moves from the maintenance to the fattening situation. The maximum weight loss due to cold stress in the average winter shown in Table 4.1 (ii) is 27.19 kg. The value of this, at £20 per cwt liveweight is about £10. The maximum decrease in weight loss, due to housing, that provides only a slight temperature rise of 1-2°C, is of the order 7-10 kg in the average winter. This is worth £2.50 - £4 per animal, at the same value of £20 per cwt, liveweight.

On these kind of figures, the cost of housing must be justified on other grounds.

iv. Management has a choice between housing or additional feed to lower the risk of cold stress. We may comment on the basis of Table 5 and Table 2.1 (iv), that where a mixed ration of hay and barley is being fed (ration concentrations 2.2 - 3.0), the additional daily intake of .1 kg barley or .15 kg hay for the 200 kg animal will lower the Critical Termperature by 1°C; for the 400 kg animal, the corresponding quantities are .2 kg barley or .3 kg hay. For a 2°C lowering of the Critical Temperature, these quantities are doubled.

Over a winter season of November through to March (162 days) the equivalent of a house providing a 1°C lift is provided by the additional feeding of 16.2 kg barley (.3 cwt) or of 24.3 kg hay (.45 cwt).

For a house providing a 2°C lift, the corresponding figures are .6 cwt barley or .9 cwt hay.

In this way, we obtain an alternative measure of the value of housing.

Meteorological Office
Cambridge

June 1973